

# STUDY OF GLOBAL RIVER BASINS USING NASA SATELLITE AND MODEL DATA

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# OUTLINE

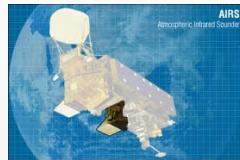
- Statement of the problem
- NASA satellite sensors for water resources
- Co-variability in hydrology
- Temporal variability
- Empirical Orthogonal Functions
- Future work

# STATEMENT OF THE PROBLEM

- The increasing trend of floods and droughts over the past decade has made the study of hydrologic processes and water availability vital to our understanding of these extreme events.
- Many of these extreme events occur in developing countries where in-situ observing networks are sparse making forecasting, and estimation of impacts near impossible.
- With the data from NASA Earth Observing Satellites and from the Global Land Data Assimilation System are used to measure changes in eleven river basins globally.

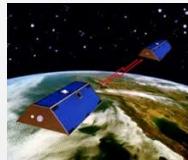
**AIRS**

Water vapor profile, clouds  
Air temperature profile,  
Surface temperature 12.5km



**GRACE**

Groundwater (2002- )  
100~km



**TRMM**  
**GPM**

Precipitation  
TRMM(1998-2015) 25km 3 hourly  
GPM (2014- ), 10km, 30min



**AMSR**  
**SMAP**

Soil Moisture surface/0-5cm  
AMSR-E – C-band; SMAP – L-band  
AMSR (2002-2011) 25km  
SMAP (2015-) 36km



**SMMR**  
**SSM/I**

SMMR (1978-1987) C-band 150km  
SSM/I 1987- , Wetness, Rainfall, Clouds, 12-50km



**AVHRR**  
**MODIS**

AVHRR: NDVI, Surface temperature 4km (1980-)  
MODIS: NDVI, Surface temperature 1km (2000-); 1030a/p;  
130a/p



**Landsat**

Vegetation, Land-use land cover 30m



1980

1990

2000

2010

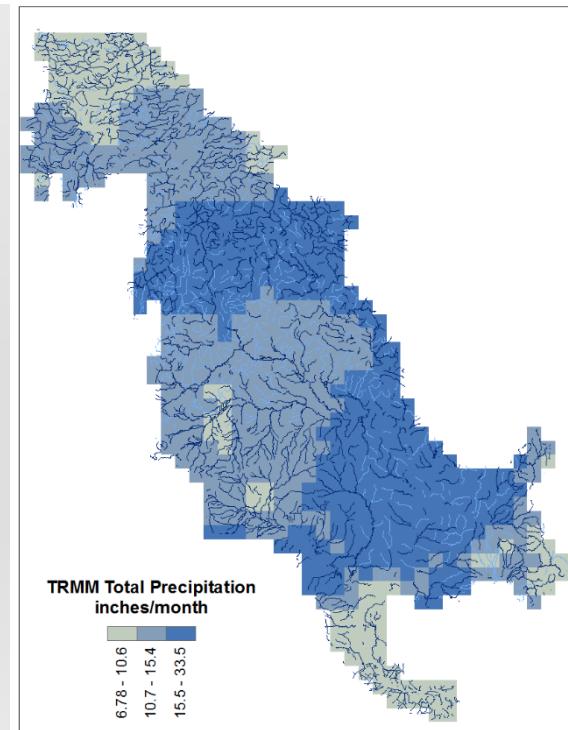
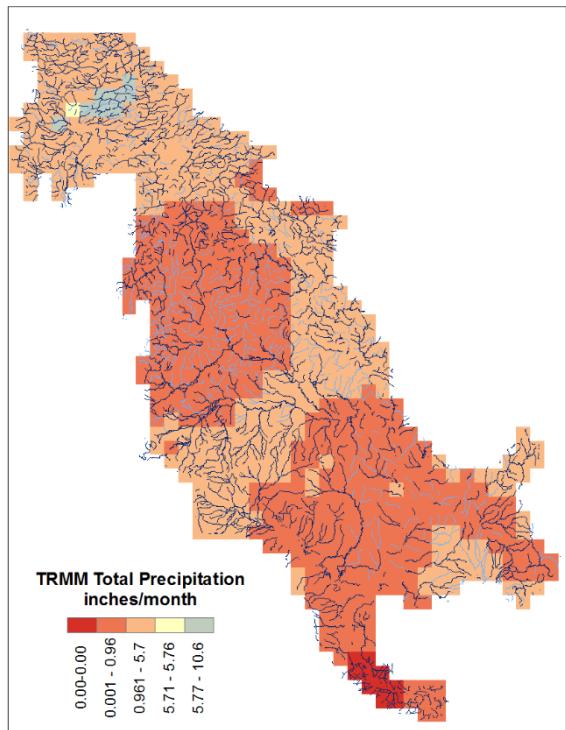
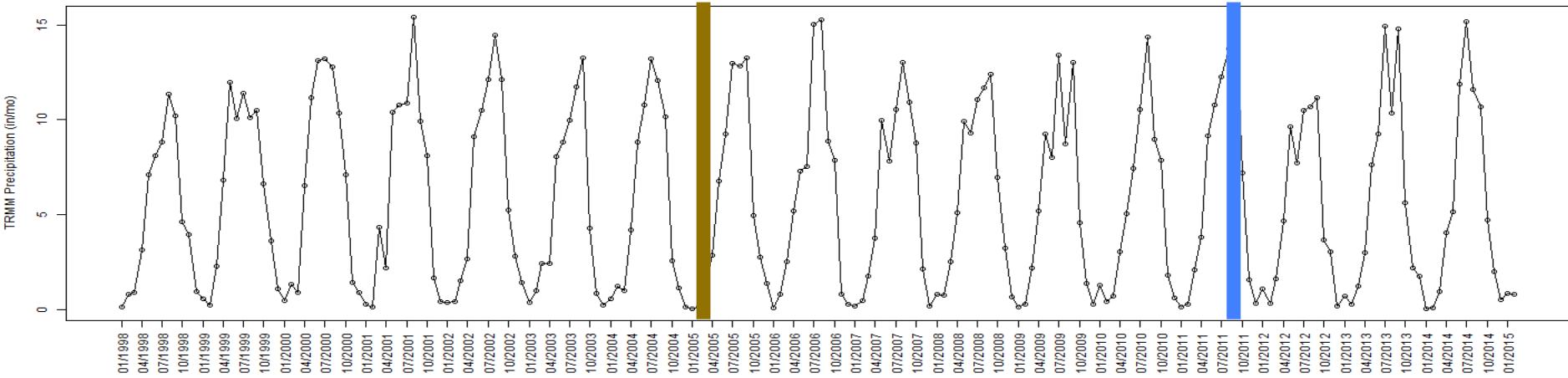
2020

CO-VARIABILITY

# TRMM Monthly Accumulated Precipitation (in)

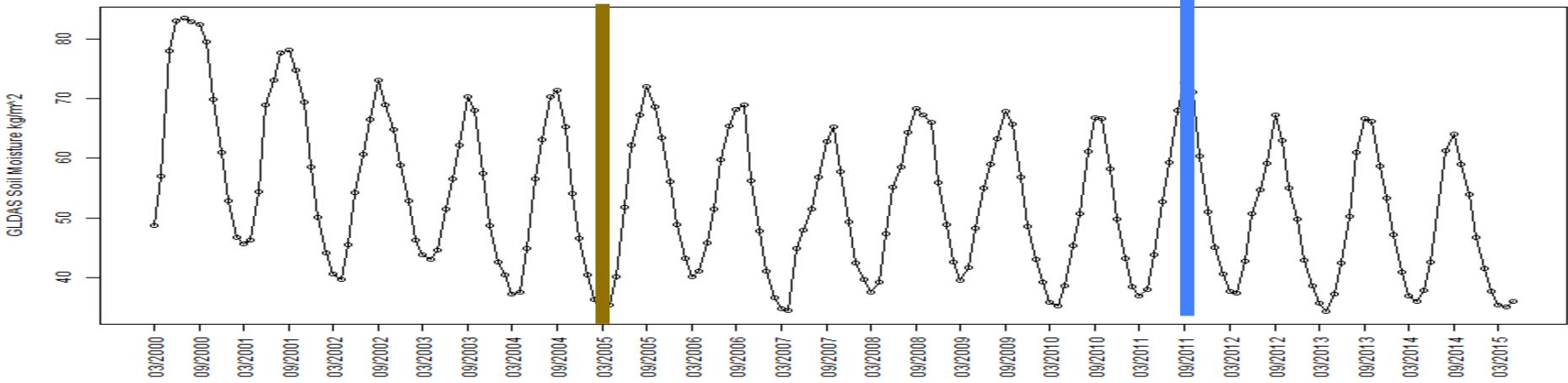
Drought: March 2005

Flood: September 2011

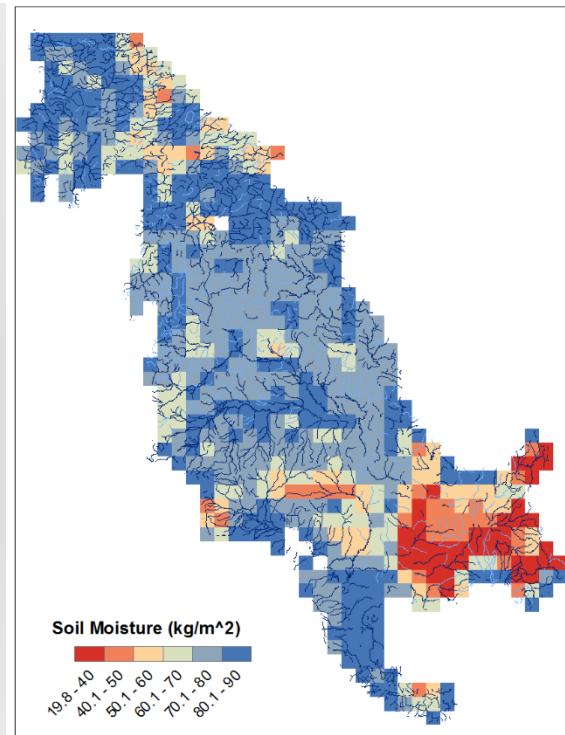
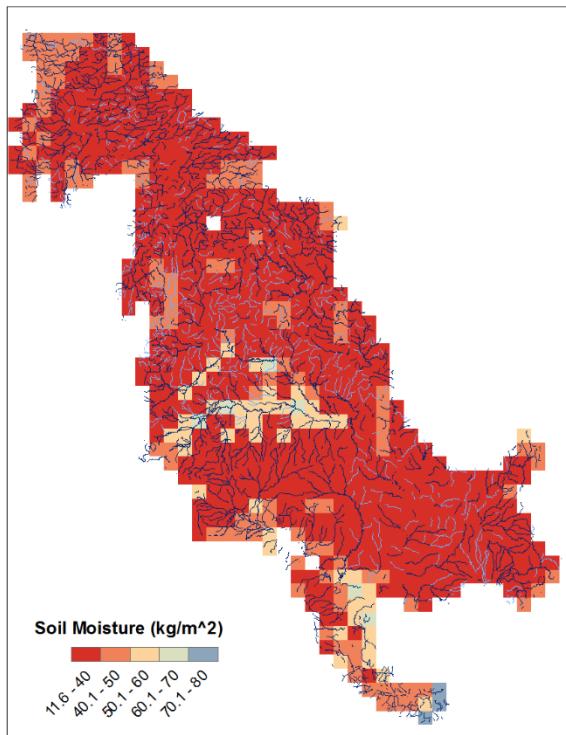


# GLDAS Soil Moisture 0-2m depth

Drought: March 2005



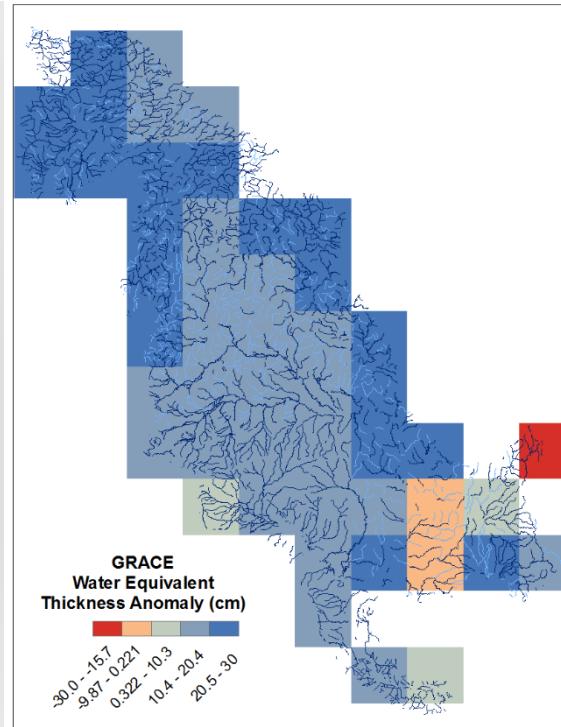
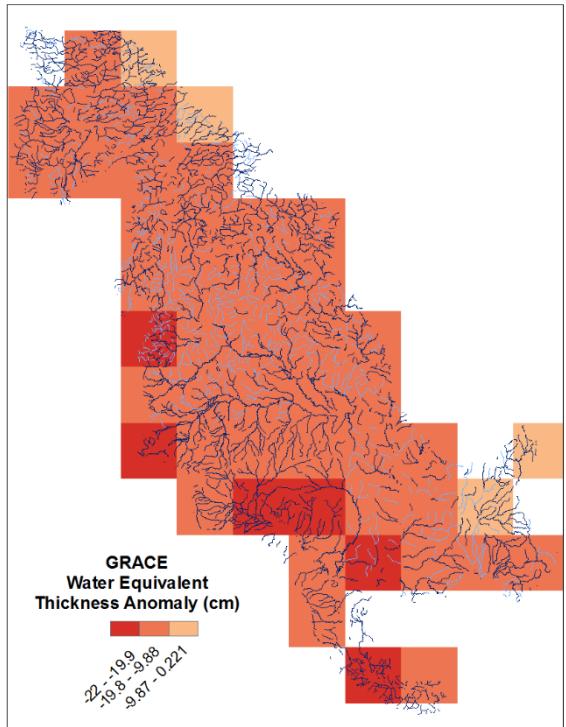
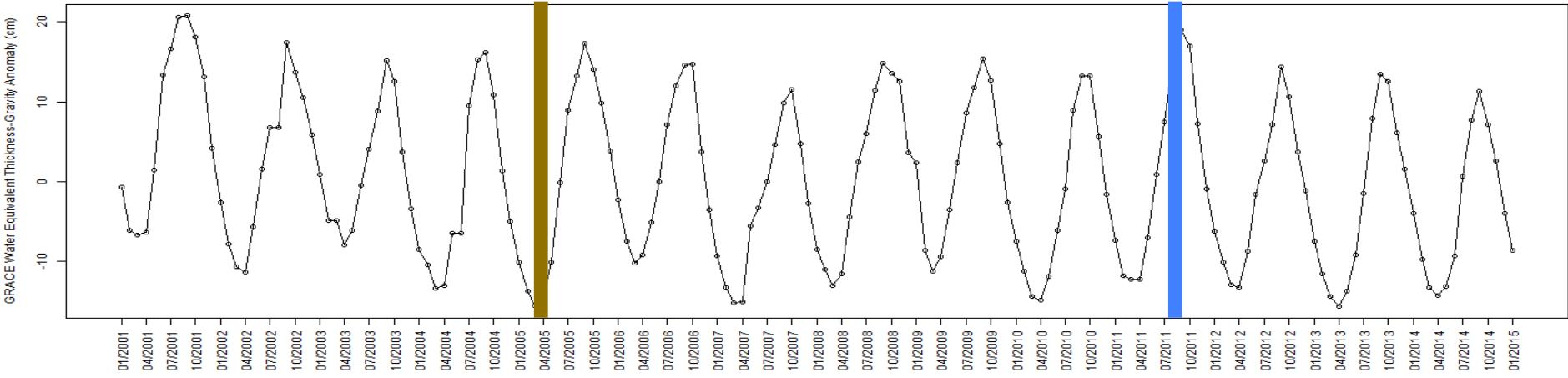
Flood: September 2011



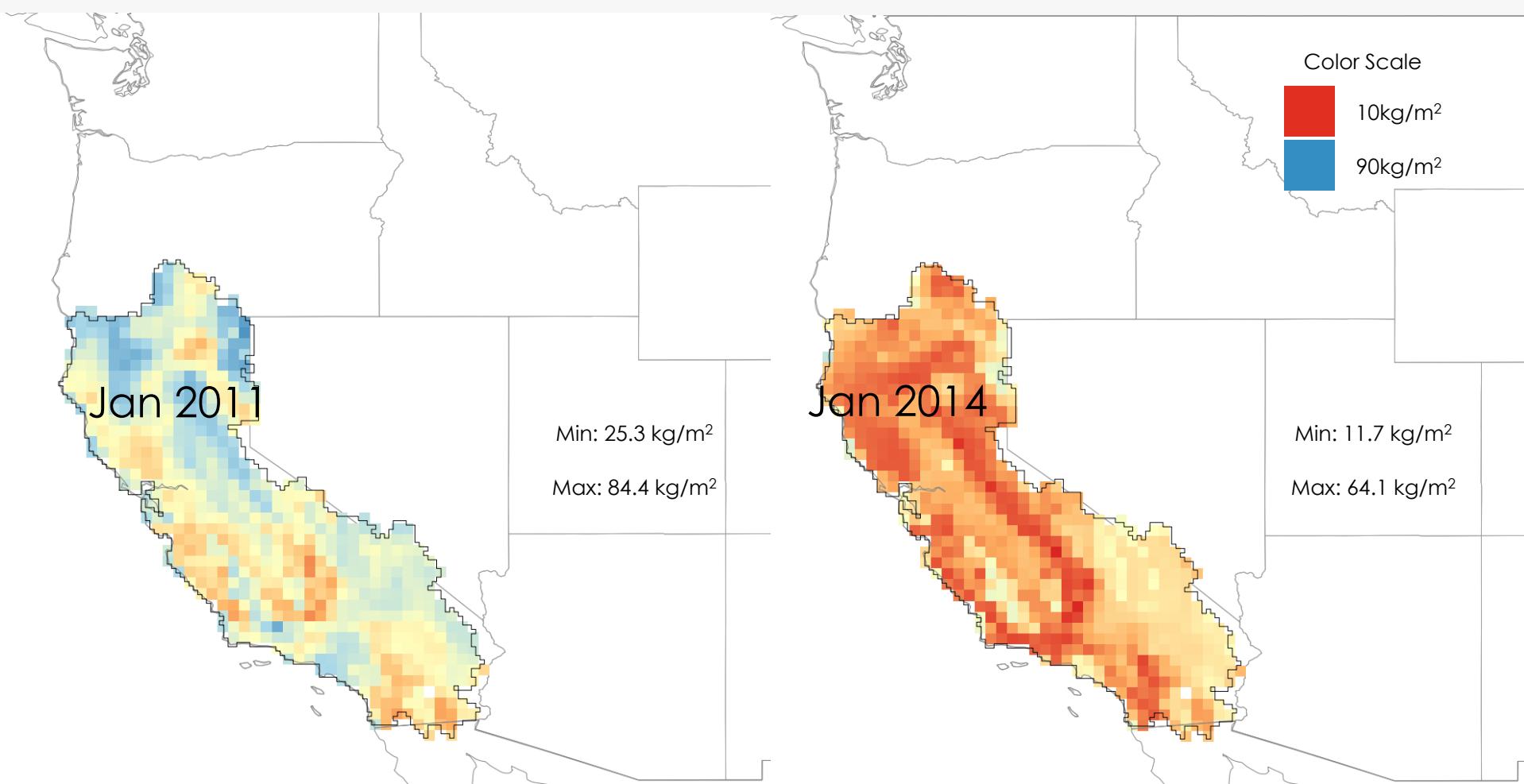
# GRACE Water Equivalent Thickness Anomaly (cm)

Drought: March 2005

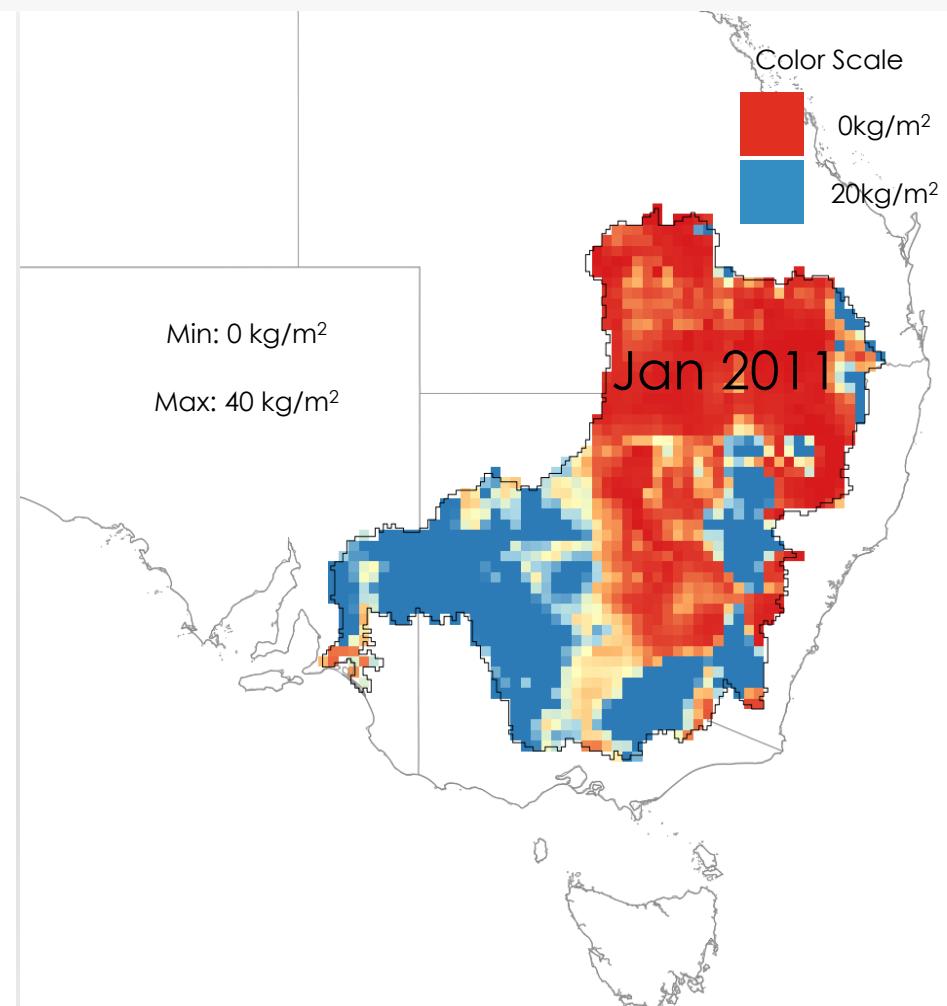
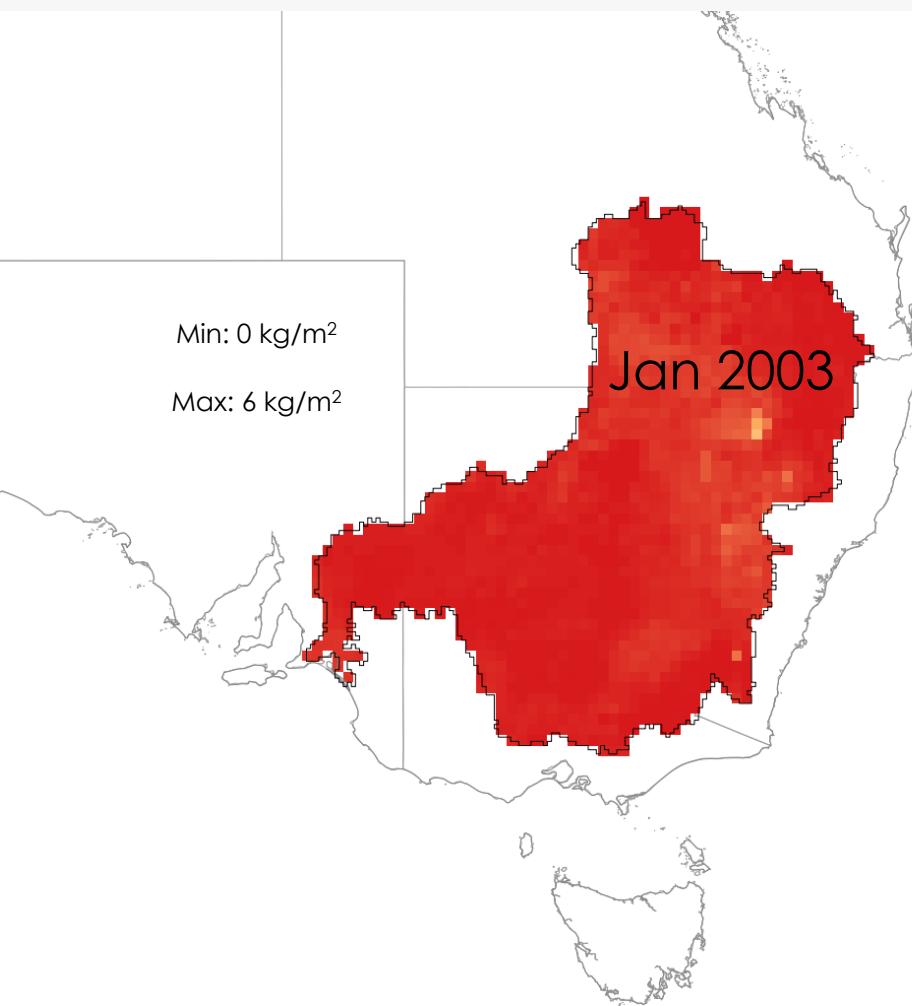
Flood: September 2011



# GLDAS Soil Moisture in the California River Basin

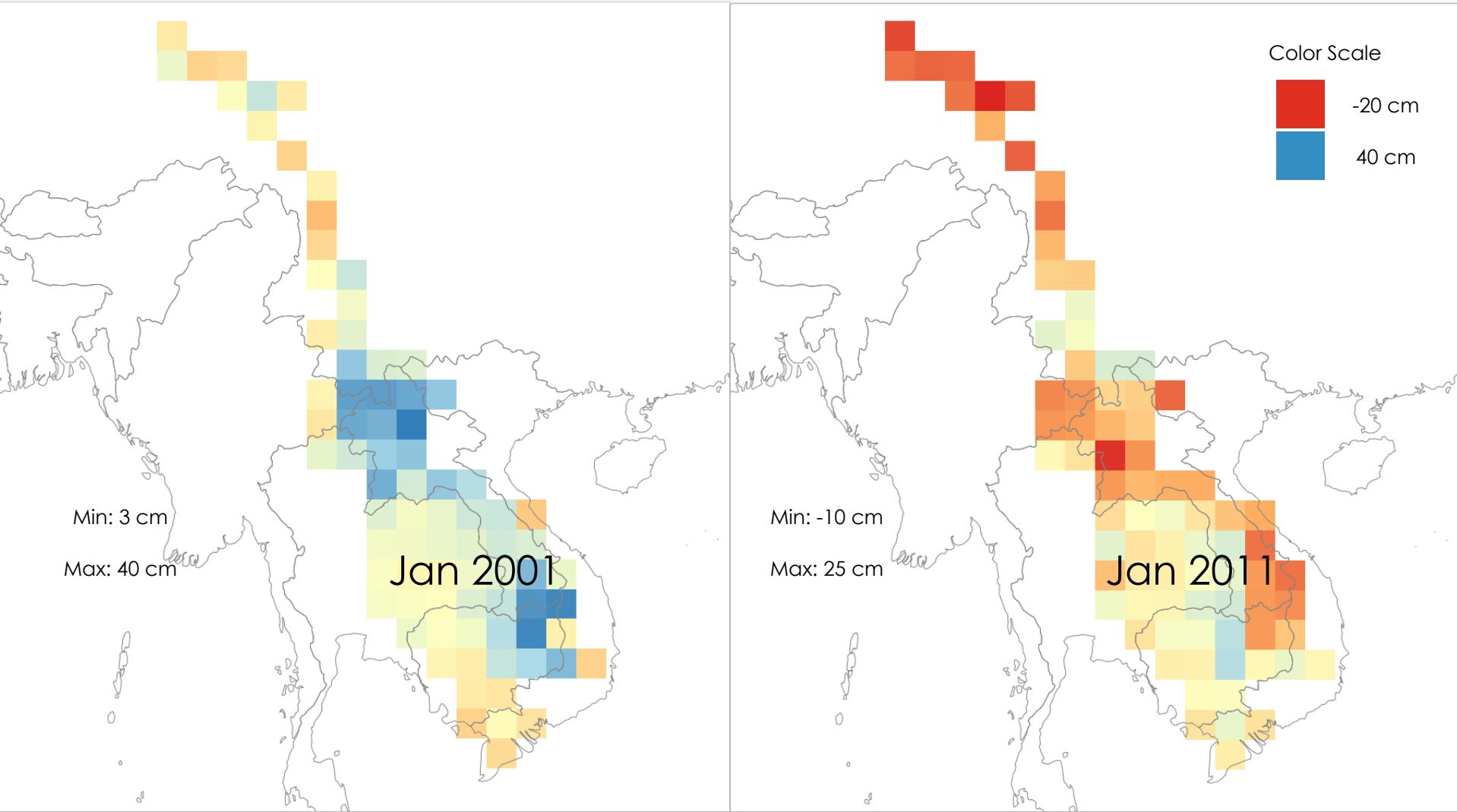
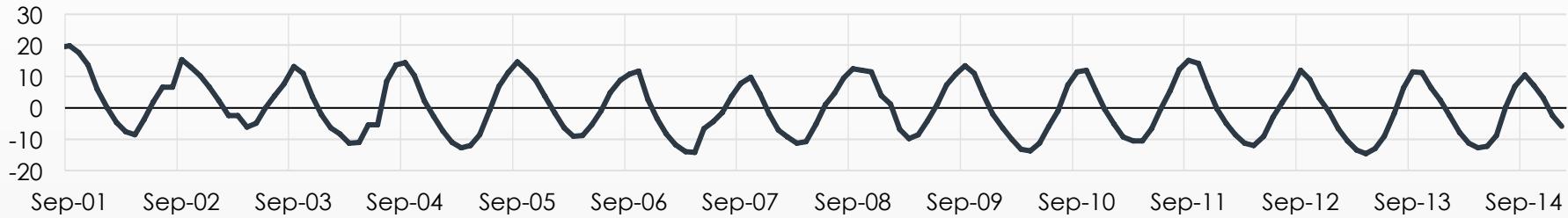


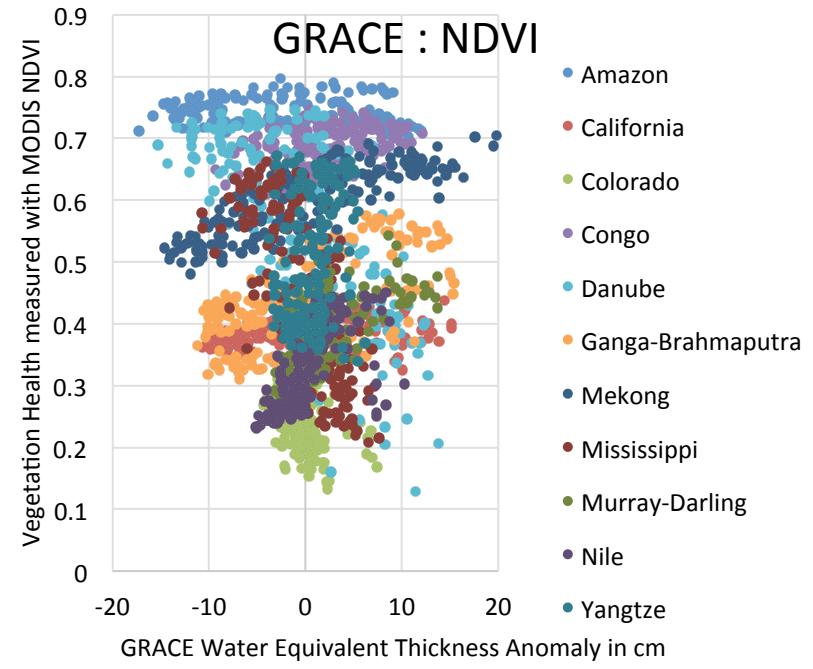
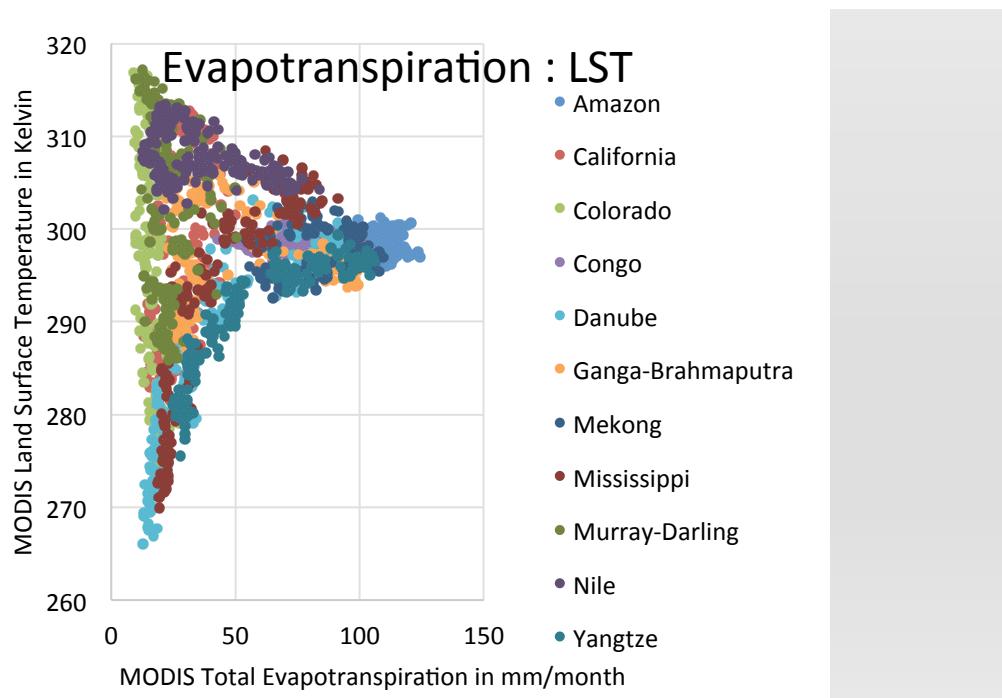
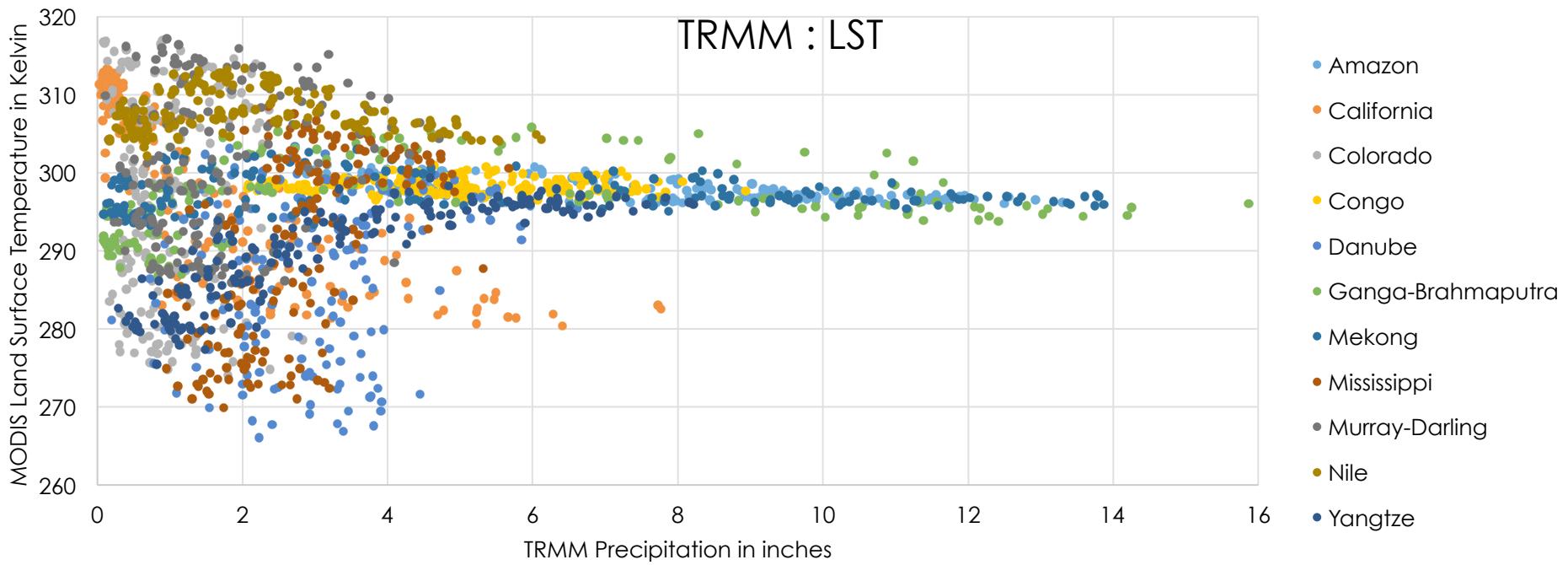
# GLDAS Runoff in the Murray-Darling River Basin



# GRACE Water Equivalent Thickness Anomaly

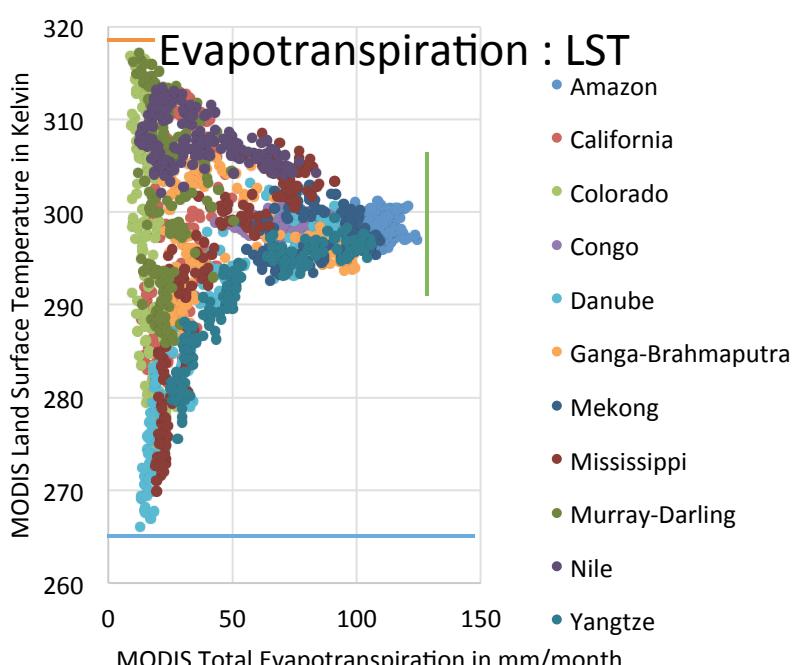
Anomaly in cm  
depth





# IMPROVING PREDICTIVE MODELING WITH CONVEX HULL

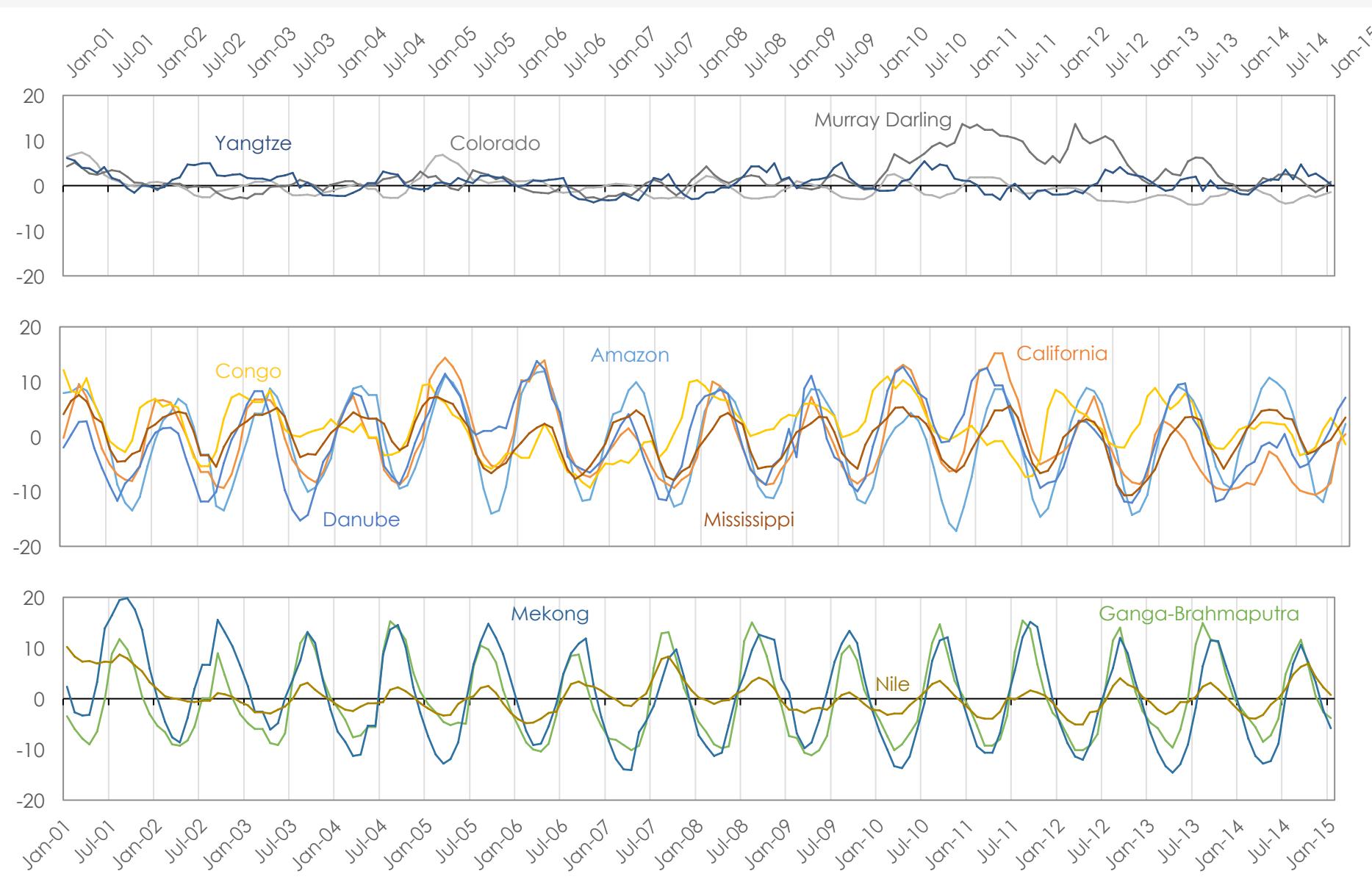
- Working backwards, co-variability plots provide a pattern by which we can expect all predicted values to match



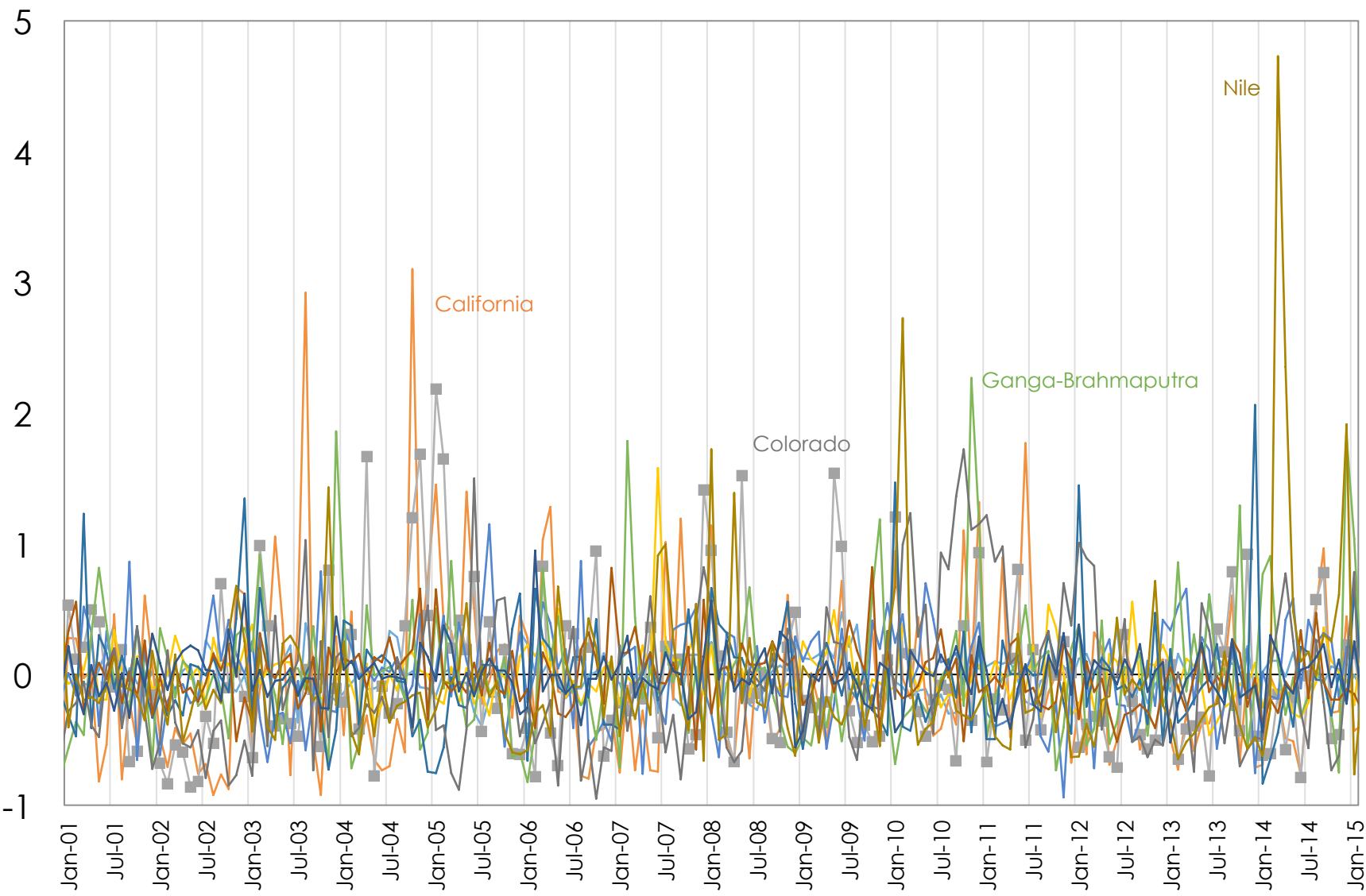
- In this case, we might say that in these global river basins:
- Surface temperature does not drop below 265K, or above 320K
- ET does not exceed 120mm/month in any region
- ET and LST is non-linearly related
- An improvement in precision of the bounding box would be to match the shape of the points, by creating a feasible region from the inside out

# TEMPORAL VARIABILITY

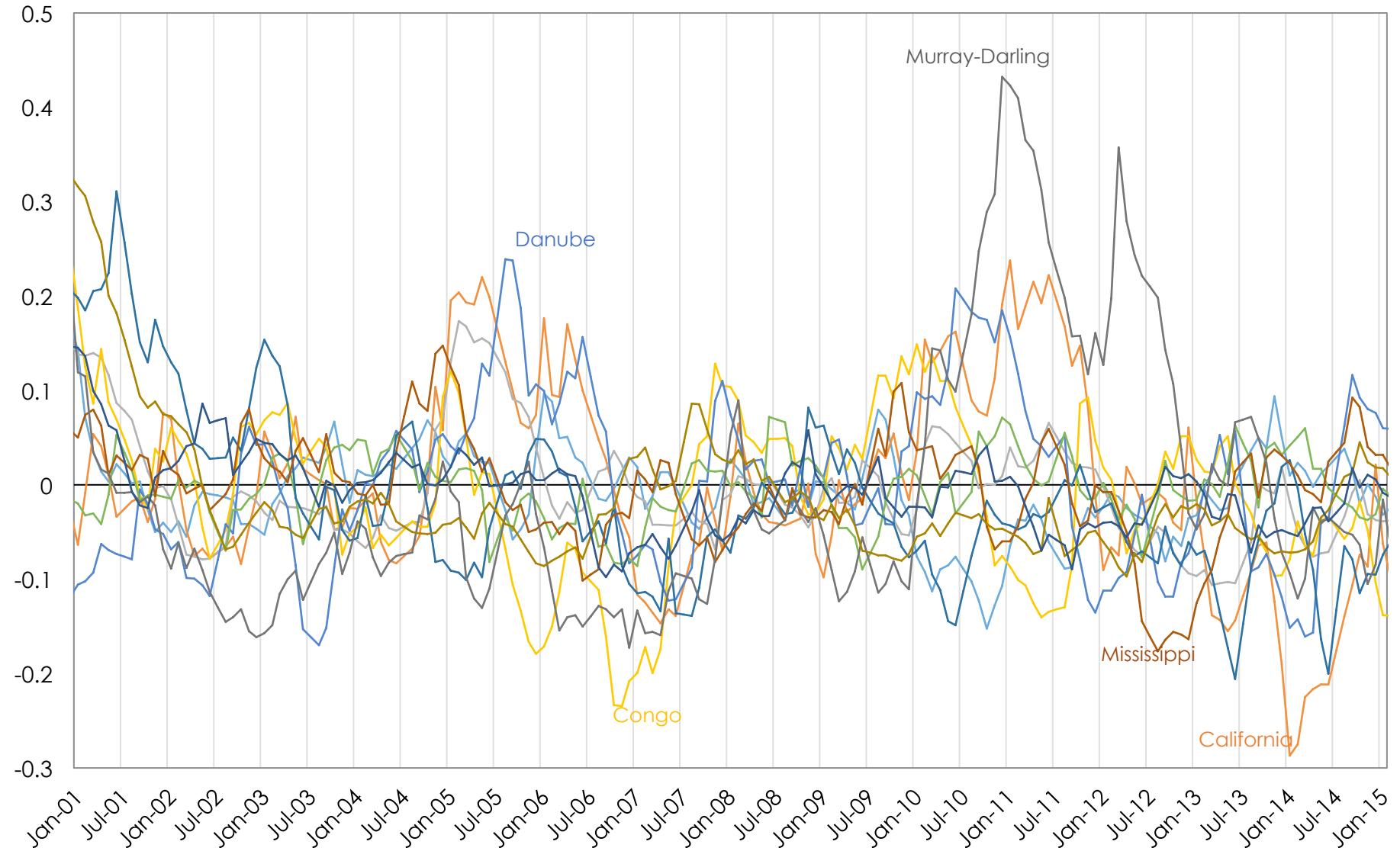
# GRACE Water Equivalent Thickness Anomaly (cm)



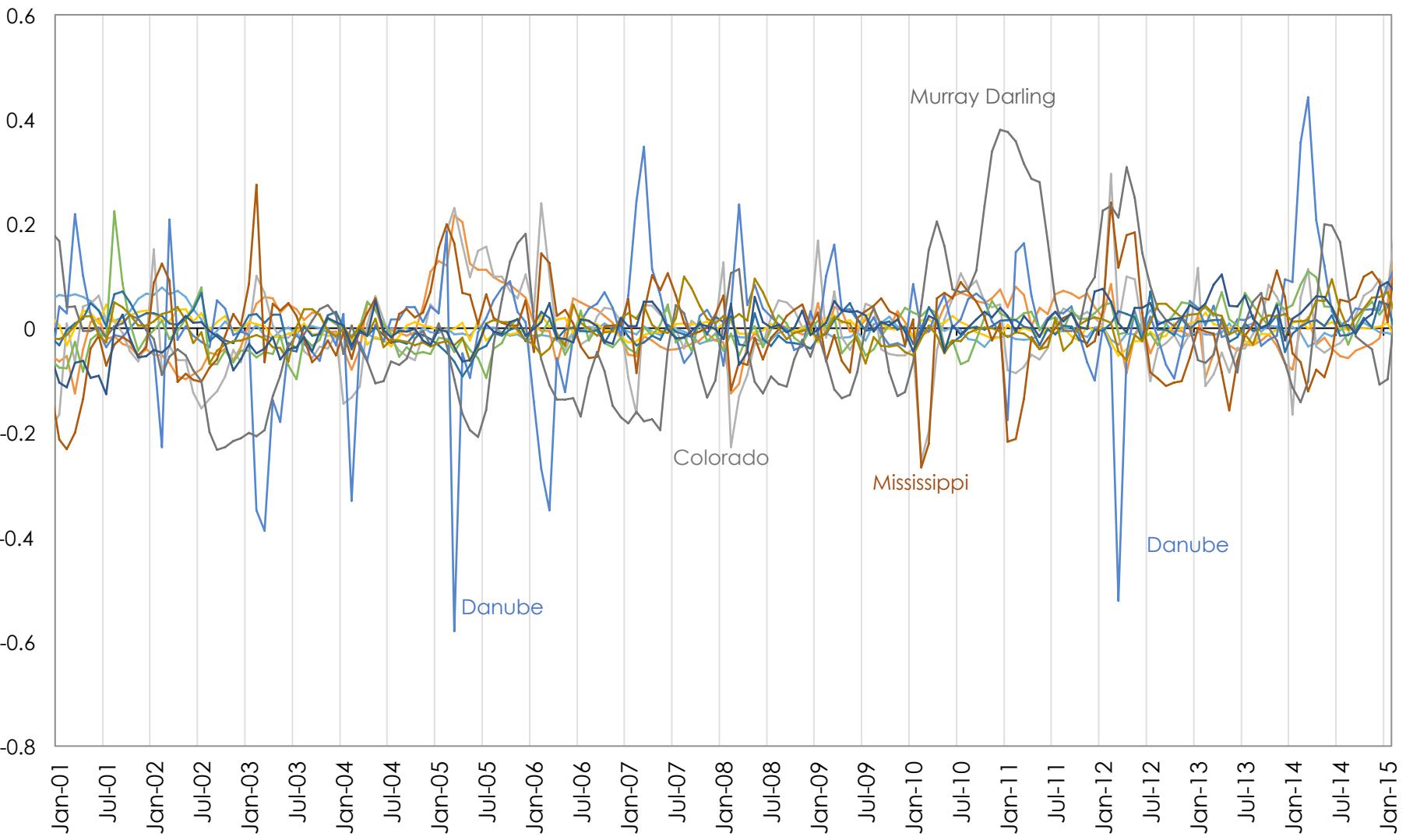
# TRMM Precipitation Anomaly Index



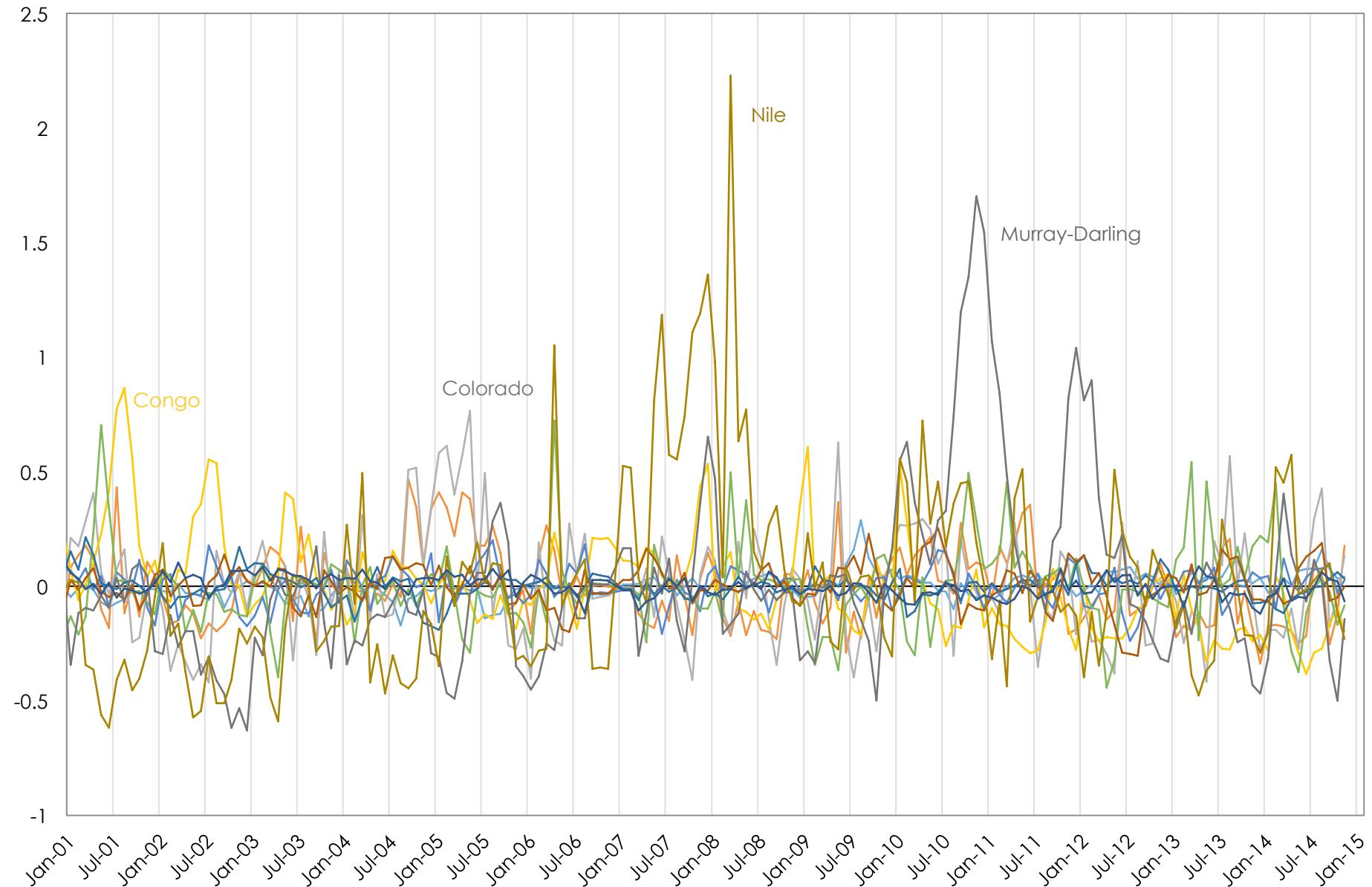
# GLDAS Soil Moisture Anomaly Index



# MODIS Normalized Difference Vegetation Index Anomaly Index



# MODIS Evapotranspiration Anomaly Index



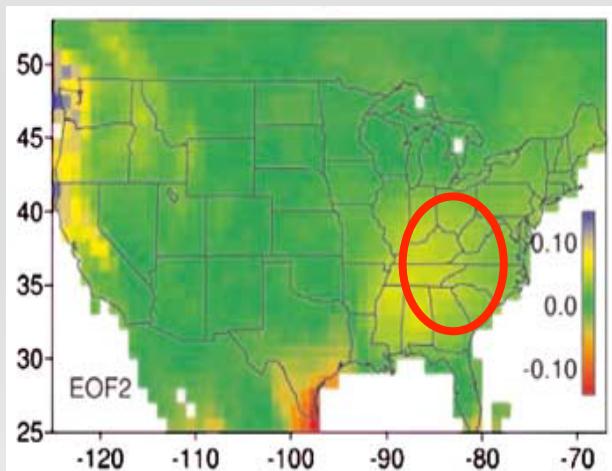
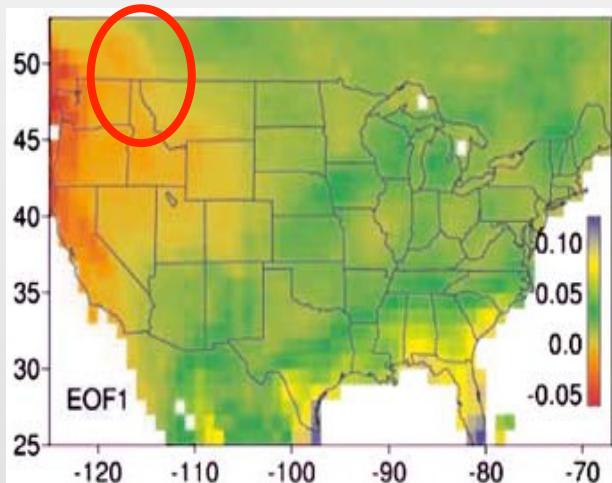
	TRMM Precipitation	MODIS NDVI	MODIS LST	MODIS ET	GLDAS Runoff	GLDAS Soil Moisture	GRACE Water Thickness
Amazon	-0.4 / 0.61	-0.04 / 0.08	0/0*	-0.17/0.29	-0.66/2.6	-0.39/0.23	-17.23/11.93
California	-0.92 / 3.47	-0.17/0.22	-0.02/0.02	-0.34/0.47	-0.86/2.33	-0.37/0.24	-10.61/15.14
Colorado	-0.93 / 2.18	-0.25/0.3	-0.02/0.02	-0.42/0.76	-0.78/2.72	-0.38/0.18	-4.33 / 7.44
Congo	-0.46 / 1.58	-0.05/0.05	0/0*	-0.38/0.86	-0.85/3.22	-0.41/0.27	-9.32/12.18
Danube	-0.94/1.15	-0.58/0.44	-0.03/0.02	-0.24/0.2	-0.78/1.85	-0.44/0.24	-15.29/13.75
Ganga Brahmaputra	-0.83 / 2.27	-0.13/0.22	-0.01/0.01	-0.44/0.72	-0.56/1.44	-0.41/0.15	-11.2/15.43
Mekong	-0.84 / 2.06	-0.09/0.09	-0.01/0.01	-0.19/0.21	-0.83/9.2	-0.42/0.68	-14.62/19.86
Mississippi	-0.58/0.82	-0.27/0.27	-0.02/0.02	-0.3/0.25	-0.76/1.52	-0.46/0.15	-10.72/7.59
Murray Darling	-0.95 / 1.73	-0.23/0.38	-0.03/0.02	-0.63/1.7	-0.83/3.04	-0.41/0.43	-3.11/13.69
Nile	-0.76 / 4.73	-0.07/0.1	-0.01/0.01	-0.62/2.23	-0.63/5.44	-0.37/0.34	-5.09/10.28
Yangtze	-0.61 / 0.95	-0.16/0.1	-0.01/0.01	-0.12/0.12	-0.61/2.91	-0.36/0.17	-3.75/6.16

# EMPIRICAL ORTHOGONAL FUNCTIONS

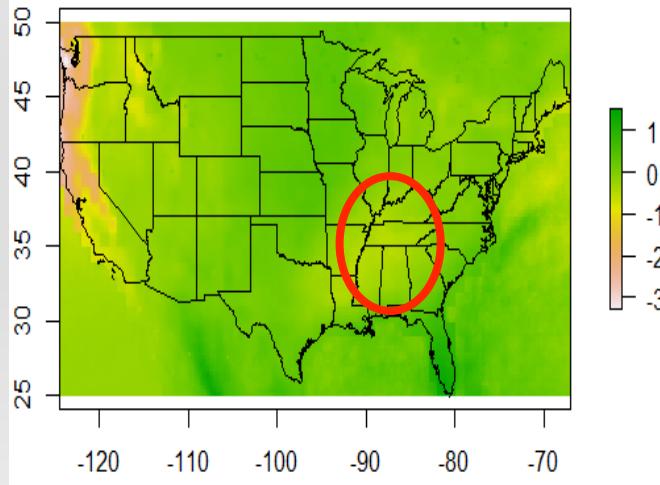
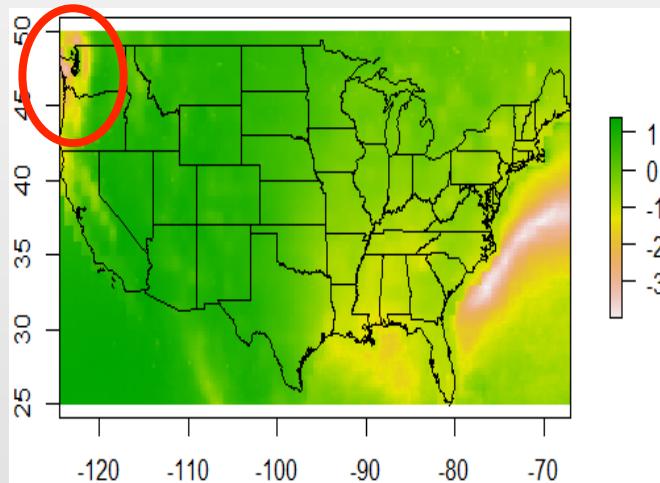
Syed, H., V. Lakshmi, D. Lohmann, K. Mitchell, E. Paleologos, Spatial correlation and temporal persistence of hydrological fluxes, *Journal of Geophysical Research (Atmospheres)*, Vol. 109, D22105, doi:0.1029/2004 JD004640, 2004

# PRECIPITATION

SYED STUDY 1997-1999  
(NLDAS)

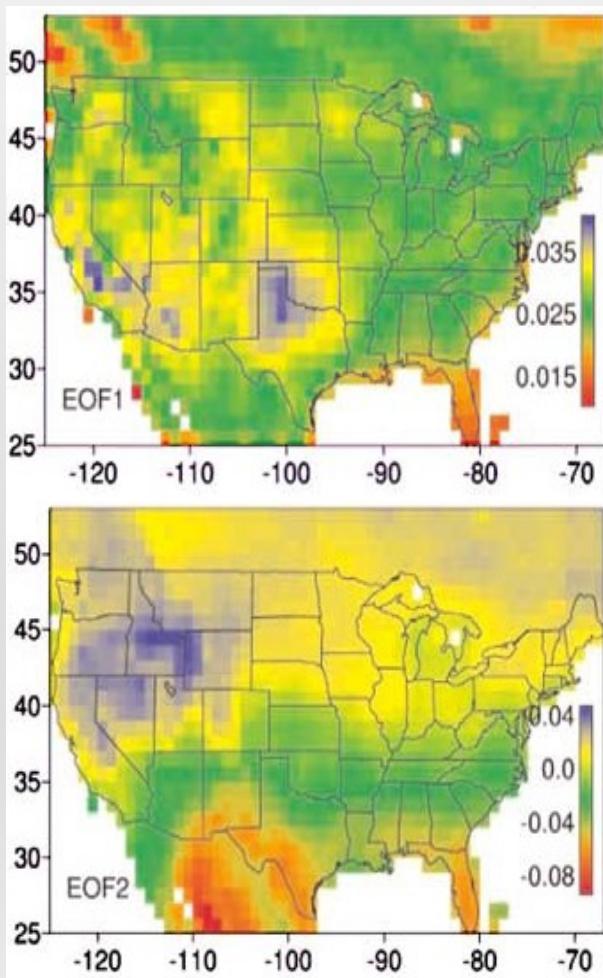


PRESENT STUDY 2000-2014  
(TRMM-MONTHLY)

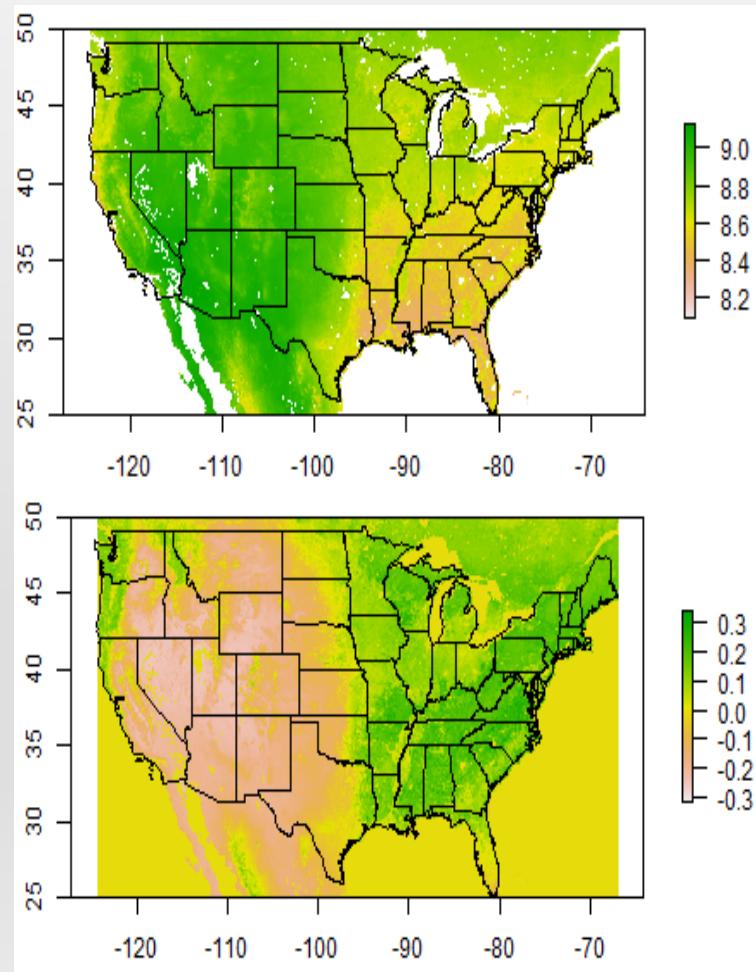


# EVAPOTRANSPIRATION

SYED STUDY 1997-1999  
(POTENTIAL-NLDAS)

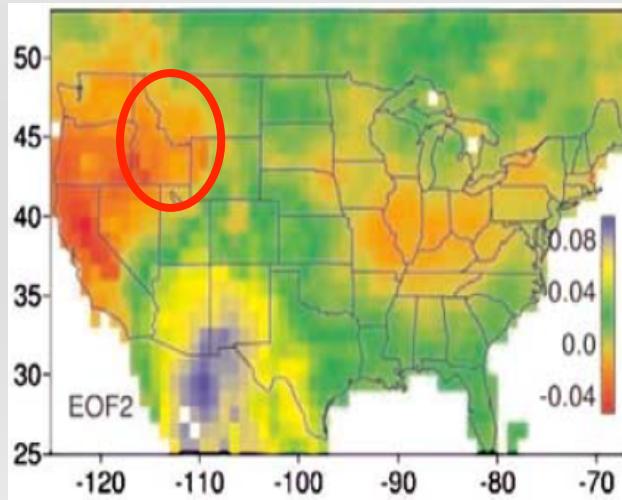
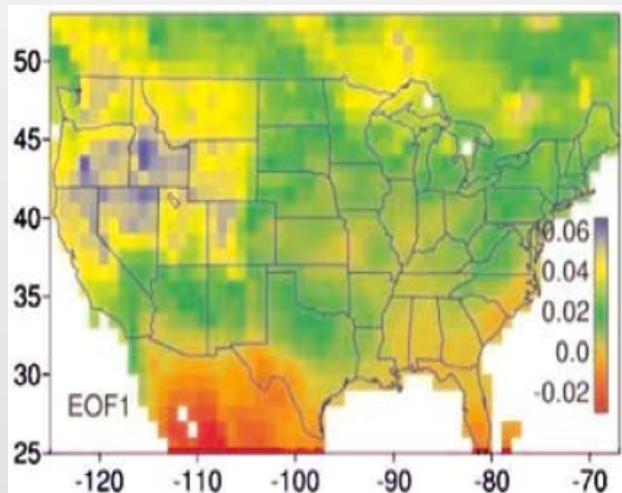


PRESENT STUDY 2000-2014  
(MODIS ET)

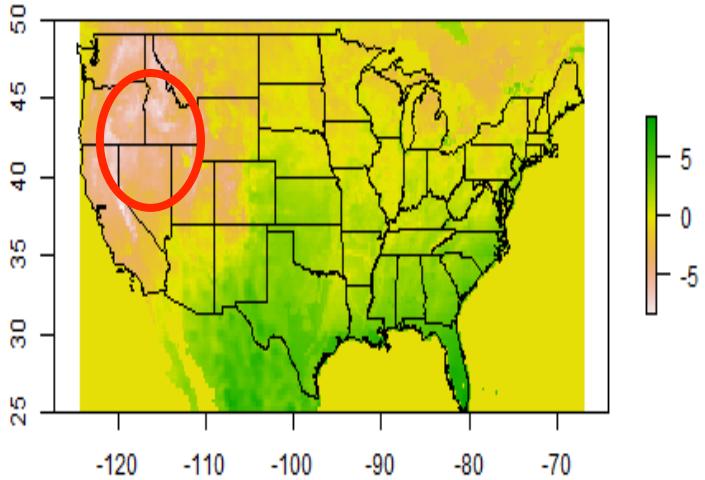
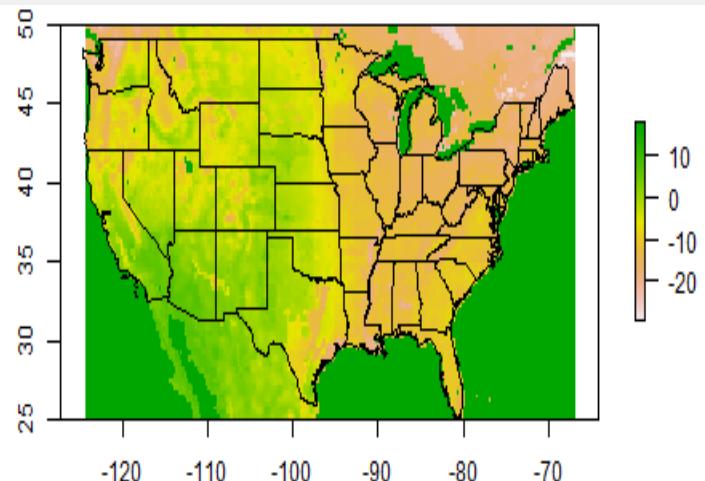


# TOP LAYER SOIL MOISTURE

SYED STUDY 1997-1999  
(NLDAS)



PRESENT STUDY 2000-2014  
(GLDAS)



# FUTURE WORK

- Spatial and temporal analysis to determine variability of elements of the hydrological cycle
- Using climate basin averaged values to compute PCA to extract variables to input into a regression formula to estimate GRACE values at a higher spatial resolution
- Lag correlation analysis to predict fluctuations in water availability
- Hierarchical cluster analysis will identify climate zone similarities across basins

THANK YOU